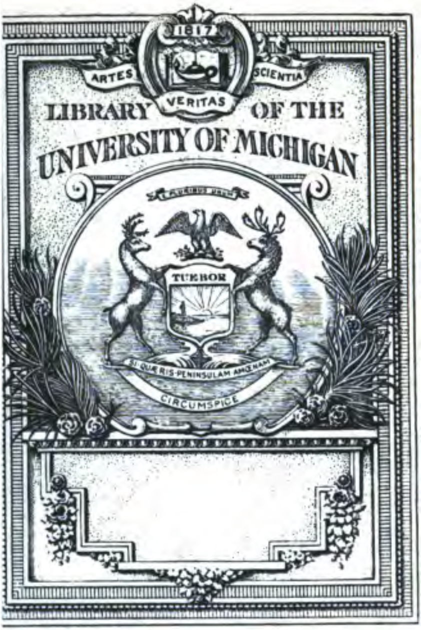
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CIRCUMSPICE

SCIENTIFIC KNOWLEDGE:

BEING AN EPITOME OF

MATHEMATICS & ASTRONOMY;

EMBRACING

INFINITE MENTAL ARITHMETIC,

DECIMAL MENTAL ARITHMETIC,

A GENERAL CANCELING SYSTEM OF ARITHMETIC,

RATIONAL MNEMONICS,

AND

A PERPETUAL MENTAL ALMANAC.

BY J. W. BOXELL.

A principle made practical, is a principle made useful.

ZANESVILLE, OHIO:

PRINTED FOR THE AUTHOR, BY PARKE & BENNETT.

1846.

EXPLANATION OF CHARACTERS.

Signs.	Signification.
$=$	Signifies equal, as \$1=100 cents.
$+$	" more, or Addition; as $6+4=10$.
$-$	" less, or Subtraction; as $6-4=2$.
$\times$	" Multiplication; as $5\times4=20$.
$\div$	" Division; as $8\div4=2$.
$\frac{8}{4}$	" " as $\frac{8}{4}=2$
|	" Division; the figures on the right hand side of the line, being divided by those on the left.
—4 | 4—	Signifies that the figures on each side of the perpendicular line, thus marked, are canceled.
: :: :	Signifies Proportion; as 2 : 4 :: 6 : 12. That is, as 2 is to 4, so is 6 to 12.
5^2	Denotes that 5 is to be squared; as $5^2=25$.
$\surd$	Signifies the square root of the number before which it is placed; as, $\surd 25=5$.

PREFACE.

The Author of this little work is under the impression that it contains a brief collection of useful knowledge, not found in any other book.

The first part, which I have called "Infinite Mental Arithmetic," being a method of combining numbers in a regular order, to any extent, in the mind, I claim as entirely *original*. If this method of combining numbers is contained in any other work, I am not aware of it: nor have I yet conversed with any person on the subject, to whom the principle was not new.

"Part second," which I have called "Decimal Mental Arithmetic" is also original *with me*. At the time when I discovered this principle, I did not know that any other person had combined numbers the same way. I soon found that I could apply it advantageously, and that the practice increased my power of calculation, and strengthened my memory. I have since learned that ZERAH COLBURN combined numbers in a similar manner.

The "Canceling system" has been applied to some extent by various authors; but I have given a general rule for *stating* questions for cancelation, which I have not seen in any other work.

It is not pretended that all questions can be wrought by this method, better than by the usual method, but wherever the principle can be applied, and it can be applied in a great majority of business questions, with advantage, it is certainly a saving of time and labor.

The principles of Mnemonics have been practiced from the earliest ages. The science is founded upon the association of ideas.

The "Perpetual Mental Almanac," with a trifling exception, is *original* throughout.

The symbols and numbers for the Moon's Phases, &c., are arranged from original calculations, and may be relied upon as correct.

To state that it is the production of an unlearned Farmer Boy, is a sufficient apology for the imperfections of this little work; but the author fully believes it will be *worth its price* to those that study its contents.

In conclusion it is respectfully submitted to the Public.

JOHN WILLIAM BOXELL.

NUMERATION TABLE.

Trillions.			Billions.			Millions.			Thousands			Units.		
Hundreds of Trillions,	Tens of Trillions,	Trillions,	Hundreds of Billions,	Tens of Billions,	Billions,	Hundreds of Millions,	Tens of Millions,	Millions,	Hundreds of Thousands,	Tens of Thousands;	Thousands,	Hundreds.	Tens,	Units,
3	4	5,	6	7	8,	1	2	9,	8	4	3,	6	5	8

Trillions are succeeded by Quadrillions, Quintillions, Sextillions, Septillions, Octillions, Nonillions, Decillions, Undecillions, Duodecillions, Tredecillions, &c., three figures being appropriated to each. This is according to the *French* method of counting.

The *English* after hundreds of millions, reckon thousands, tens and hundreds of thousands of millions, appropriating *six* places, instead of three, to millions, billions, trillions, &c.

PART FIRST.

INFINITE MENTAL ARITHMETIC.

This is a New and Original Method of Combining Numbers, without the usual operation on the slate. By which the operations of Addition, Subtraction, Multiplication, Division, Squaring Numbers, Extracting the Square Root, &c. can be performed in the mind to any extent whatever, with any amount or number of figures; and the answers given instantaneously.

CASE 1.

TO SQUARE ANY NUMBER OF 1s.

Observation.—The product or square, of any number of 1s, will contain twice as many figures, lacking one, as the number of 1s squared. These figures are always in a regular order, and when the number of 1s squared does not exceed nine, the figures of the product increase from the right hand 1, or unit's figure, to that figure, which is the number of 1s squared, which is always the middle figure, then decrease in the same order to the left hand 1.

Or write down that figure which is the number of 1s, to be squared, and fill it out on each side down to 1. This will be readily understood, by looking at the answers of the following examples, and working out a few operations on the slate.

EXAMPLES.

1. Square three 1s. Ans. 12321.
2. Square six 1s. Ans. 12345654321.
3. Square five 1s.

```
    11111
    11111
    -----
    11111
   11111
  11111
 11111
11111
---------
```

Ans. 123,454,321.

4. Square nine 1s. Ans. 12,345,678,987,654,321.

Observation 2. As the operation when performed on the slate, consists merely in adding 1s, in a regular order from 1 up to the number squared, then down in the same order, or inversely, to 1 again, the only thing to be observed when the number of 1s to be squared exceeds nine, is to carry. The principle is still the same.

5. Square ten 1s. Ans. 1234567900987654321.
6. Square eleven 1s. Ans. 123456790120987654321.
7 Square twelve 1s.
Ans. 12345679012320987654321.
8 Square fifteen 1s.
Ans. 1234567901234565432098765432l.

In the square of ten 1s, you observe, the order of the figures is as before, from the unit figure to the middle figure, which is a cipher, the next a cipher, and the order as before down to the left hand 1, except that the 8 is omitted.

The reason will be obvious by working it out. The highest number of 1s added, is ten, the middle figure of course, must be a cipher, the next column to the left is nine 1s, and 1 to carry is ten, another cipher, the next eight 1s, and 1 to carry is 9, next seven 1s and none to carry, next six and so on down to 1. In squaring eleven 1s, the figures are the same from the right to the middle figure. The highest number of 1s is eleven, 1 to carry is twelve, therefore, the middle figure is 2, the next is 1, the number of 1s being ten, and 1 to carry, the next a cipher, and down to the left as before. In the square of twelve 1s, the middle figure is 3, the first figure on each side a 2, then down each way as in the square

of eleven 1s. In the square of fifteen 1s, the figures increase from the units figure up to 9, then 0, next 2, &c. up to 6, the middle figure; then down again to 0, then 9, next 7, and down to the left hand 1. In the square of any other number of 1s, the order of the figures, each way from the middle is the same, the middle figure ascending 1 higher than the number of 1s squared, up to nineteen 1s, when the 1 to carry in the middle making 20, the order of the figures in the middle is the same as in the square of ten 1s.

In the square of twenty 1s, the figures in the middle are as in the square of eleven 1s. In the square of twenty three 1s, the middle figure will be 5, in twenty five 1s, 7, being 2 to carry, and so on to twenty eight 1s, when the 2 to carry will make 30, and the figures in the middle as in the square of nineteen 1s. Then there will be 3 to carry in the middle, and the middle, 3 higher than the number of 1s squared, up to thirtyseven 1s, when the 3 to carry in the middle will make 40, and the figures in the middle as at twenty eight, then 4 to carry in the middle &c.

9. Square thirty three 1s.

Ans. 12,345,679,012,345,679,012,345,679,012,345,654, 320,987,654,320,987,654,320,987,654,321. Read 12,345 decillion, 679,012 nonillion, 345,679 octillion, 012,345 septillion, 679,012 sextillion, 345,654 quintillion, 320,987 quadrillion, 654,320 trillion, 987,654 billion, 320,987 million, 654 thousand, 321.

It will be seen from the above, that to give the square of any number of 1s, it is only necessary to commence at 1, on the right or left, and set down the ten figures in their order, omitting the 1s, from the right to the middle, and the 8s, from the middle to the left.

And by remembering the number of figures to be in the answer, the number to carry in the middle, and how far the middle figure will go above the number of 1s squared, with a little practice, the square of any number of 1s up to one hundred or more, can be read off from the mind without hesitation.

CASE 2.

TO SQUARE ANY NUMBER OF 2s.

EXAMPLES.

1. Square three 2s. Ans. 49284.
2. Square four 2s. Ans. 4937284.

3. Square eight 2s. Ans. 493827150617284.
4. Square twelve 2s.

Ans. 49,382,716,049,283,950,617,284.

5. Square six 2s.

```
      222222
      222222
      ------
      444444
     444444
    444444
   444444
  444444
 444444
-----------
Ans. 49,382,617,284.
```

Note.—As multiplying 2s by 2s, produces 4s, to square any number of 2s, it is only necessary to add 4s in a regular order from one 4 on the right, up to the middle, or number of 2s squared, then down to one 4 on the left.

It is not at all necessary to perform the multiplication on the slate, as the 4s can be added in the mind, and the answer written down as fast as the figures can be made. The student will perceive that a little practice will enable him to write down the square of any number up to twenty or thirty 2s readily.

CASE 3.

TO SQUARE ANY NUMBER OF 3s.

EXAMPLES.

1. Square four 3s.

```
      3333
      3333
      ----
      9999
     9999
    9999
   9999
  --------
Ans. 11108889.
```

Obs. 1. From the above example it will be seen, that the rule for squaring 2s will answer for squaring 3s; except that the figures added are 9s.

Obs. 2. The square of any number of 3s, will contain twice as many figures as the number of 3s squared, these figures are always in a certain order, the units figure being 9, the rest all 8s to the middle, the first figure to the left of the middle is 0, then all to the left of that are 1s.

Ex. 2. Square nineteen 3s.

Ans. 11,111,111,111,111,111,108,888,888,888,888,888,889.

Read, 11 undecillion, 111 decillion, 111 nonillion, 111 octillion, 111 septillion, 111 sextillion, 108 quintillion, 888 quadrillion, 888 trillion, 888 billion, 888 million, 888 thousand, 889.

A knowledge of Numeration is the only thing requisite to enable a person instantly to tell the square of any number of 3s from the mind.

CASE 4.

TO SQUARE ANY NUMBER OF 4s.

EXAMPLES.

1. Square three 4s. Ans. 197136.
2. Square seven 4s.

```
        4444444
        4444444
       ---------
       17777776
      17777776
     17777776
    17777776
   17777776
  17777776
 17777776
 --------------
 19753082469136
```

Ans. 19753082469136.

Remarks. A glance at the example above will show that the usual operation in squaring 4s can be dispensed with. In squaring 4s the units figure in each partial product is 6, the left hand figure 1, those between are all 7s. In adding the partial products we have twice as many columns of figures to add as the number of 4s squared; the first 6, then each column containing one 6, the rest being 7s up to that column which contains as many figures as the number of 4s squared, the next column contains the same number of figures, the upper figure being a 1, the rest 7s; each column will contain a 1, the rest being 7s, down to the left, the last being 1.

With a little practice in squaring 4s, and knowing the figures to be added, it can be done in the mind, and the answer written down as quick as the partial products can be added after we have done multiplying.

CASE 5.

TO SQUARE ANY NUMBER OF 5s.

EXAMPLES.

1. Square five 5s. Ans. 3086358025.
2. Square eight 5s.

```
       55555555
       55555555
       ---------
       277777775
      277777775
     277777775
    277777775
   277777775
  277777775
 277777775
277777775
-----------------
3086419691358025.
```

Ans. 3086419691358025.

Note. In squaring 5s the unit's figure of each partial product is 5, and the left hand figure 2, in every other respect the remarks under the preceding case will apply in this.

CASE 6.

TO SQUARE ANY NUMBER OF 6s.

EXAMPLES.

1. Square four 6s. Ans. 44435556.
2. Square six 6s.

```
     666666
     666666
     -------
     3999996
    3999996
   3999996
  3999996
 3999996
3999996
------------
444443555556.
```

Ans. 444443555556.

Obs. The square of any number of 6s contains twice as

many figures as the number squared; these are always in the same order; viz: the unit's figure 6, then all 5s to the middle, the first figure left of the middle 3, then all 4s to the left; hence, the square of any number of 6s can be given from the mind instantaneously.

3. Square twenty 6s.

Ans. 4,444,444,444,444,444,444,355,555,555,555,555,555,556.

Read 4 duodecillion, 444 undecillion, 444 decillion, 444 nonillion, 444 octillion, 444 septillion, 444 sextillion, 355 quintillion, 555 quadrillion, 555 trillion, 555 billion, 555 million, 555 thousand 556.

CASE 7.

TO SQUARE ANY NUMBER OF 7s.

EXAMPLES.

1. Square four 7s. Ans. 60481729.
2. Square five 7s. Ans. 6049261729.
3. Square six 7s.

```
          777777
          777777
     -----------
         5444439
        5444439
       5444439
      5444439
     5444439
    5444439
    ------------
Ans. 604,937,061,729.
```

Remarks. In squaring 7s the units figure of each partial product is 9, the figure of tens 3, the rest all 4s except the left hand figure which is 5. In adding the partial products we have twice as many columns to add as the number of figures squared; the first 9, the next 9 and 3, next 9, 3, and 4, next 9, 3 and two 4s; and so increasing the number of 4s to the middle, when the number of figures in the column will equal the number of figures squared, the lower figure in the column being 9, the next 3, and all the rest 4s; the first column left of the middle will contain the same number of figures, the lower one being 3, the upper one 5, and the rest 4s; the next column to the left will contain the same num-

ber of 4s and a 5, then each column will contain a 5, and the rest 4s, the 4s decreasing to the left, the left hand column will be 5.

Practice until you are familiar with the order of the figures in the partial products, and if you are expert in adding, you can write the square of any number of 7s as quick as you can make the figures.

CASE 8.

TO SQUARE ANY NUMBER OF 8s.

EXAMPLES.

1. Square four 8s. Ans. 78996544.
2. Square six 8s. Ans. 790121876544.
3. Square eight 8s.

```
          88888888
          88888888
        ----------
         711111104
        711111104
       711111104
      711111104
     711111104
    711111104
   711111104
  711111104
  ----------------
Ans. 7,901,234,409,876,544.
```

Obs. In squaring 8s the units figure of each partial product is 4, the figure of tens a cipher, the rest all 1s except the left hand figure which is 7. In adding the partial products we have twice as many columns to add as the number squared; the first 4, the next 4 and 0, the next 4, 0, and 1, the next 4, 0, and two 1s, and so increasing up to the middle, when the number of figures in the column, will equal the number of figures squared; the lower figure in the column will be 4, the next 0, and the rest 1s; the first column left of the middle will contain the same number of figures, the upper one 7, the lower one 0, and the rest 1s, the next column to the left will contain the same number of 1s and a 7, then each column will contain a 7 and the rest 1s, the 1s decreasing down to the left, the left hand figure will be 7. Multiplying

is unnecessary, as we know the figures to be added and their order, hence, the figures can be added in the mind, and the square of any number of 8s can be written down as fast as the figures can be made.

CASE 9.

TO SQUARE ANY NUMBER OF 9s.

EXAMPLES.

1. Square four 9s. Ans. 99980001.
2. Square six 9s. Ans. 999,998,000,001.
3. Square nine 9s.

```
                999999999
                999999999
                ---------
               8999999991
              8999999991
             8999999991
            8999999991
           8999999991
          8999999991
         8999999991
        8999999991
       8999999991
       ------------------
Ans.   999,999,998,000,000,001.
```

Obs. The square of any number of 9s, contains twice as many figures as the number squared. These figures are always in the same order. The units figure being 1, then all 0s, to the middle, the first figure left of the middle 8, then all to the left of that are 9s.

4. What is the square of 999,999,999,999,999?
Ans. 999,999,999,999,998,000,000,000,000,001.
5. What is the square of twenty-two 9s?
Ans. 99,999,999,999,999,999,999,980,000,000,000,000,000,000,001.

Read 99 tredecillion, 999 duodecillion, 999 undecillion, 999 decillion, 999 nonillion, 999 octillion, 999 septillion, 980 sextillion, and 1.

From the above we know the number of figures to be in the square of any number of 9s and their exact order: hence, by a thorough knowledge of Numeration, and knowing the

number of figures any Period will express; the square of any number of 9s, can be told from the mind, instantly, without writing the figures down.

CASE 10.

To multiply any number of figures of one sort, by the same number of figures of another sort.

EXAMPLE Multiply 88888 by 44444.

```
        88888
        44444
       ------
       355552
      355552
     355552
    355552
   355552
   ----------
Ans. 3,950,538,272
```

Obs. It is as easy to multiply different numbers together by this method, as to square numbers, and it is done in the same manner.

The student will perceive that the example above can be performed without multiplying figures on the slate.

To multiply figures of one sort, by figures of another sort, in the mind, by multiplying a few figures in one factor by a figure in the other, (which can be done in the mind instantly,) we can see how the figures in the partial products would stand, on the tablet of the imagination, and sum them up as fast as we can write down the result.

Note. Multiply any number of figures of one kind by an equal number of 9s, and the figures of the product will be in a regular order, the product containing as many figures as both the factors.

To multiply 1s by 9s, is the same as to square 3s: multiply any number of 2s by an equal number of 9s, the units figure of the product will be 8, from that to the middle 7s, the first figure left of the middle 1, and all to the left of that 2s: multiply 3s by 9s, the units figure of the product will be 7, then all 6s to the middle, then a 2, and all 3s to the left; the product of 4s by 9s, is the same as the square of as many 6s;

multiply 5s by 9s, the units figure of the product will be 5, then all 4s to the middle, then another 4, and the rest to the left 5s; multiply 6s by 9s, the units figure of the product will be 4, then all 3s to the middle, the first figure left of the middle 5, then all to the left 6s; multiply 7s by 9s, the units figure will be three, then all 2s to the middle, then a 6, and all to the left 7s; multiply 8s by 9s, the units figure will be 2, then all 1s to the middle, the first figure left of the middle 7, and all to the left of that 8s. Multiply 6s by 3s, the product will be the same as to multiply 2s by 9s.

The product of any number of 2s, multiplied by an equal number of 5s, is equal to the square of an equal number of 1's,—with a cipher on the right of the product.

By remembering the order of the figures, the product of any number of figures of one sort, multiplied by an equal number of 9s, can be given from the mind instantly.

CASE 11.

To give the square of any number of figures, divided by any figure that will divide each of them without a remainder, or multiplied by any figure that will not increase the figures multiplied above nine, or with any figures subtracted from them, provided the subtrahend contains the same number of figures, and the figures in the subtrahend are all alike, or with any figures added to them, provided they contain the same number of figures, all alike, and the figures when added do not exceed nine. With various combinations, &c.

EXAMPLES.

1. What is the square of 999999 divided by 3?

Ans. 111,110,888,889.

3)999999

333333

From the above example we observe that the quotient of any number of 9s divided by 3 will be a number of 3s equal to the number of 9s divided; hence, we have only to square as many 3s.

2. What is the square of 33333 multiplied by 2?

Ans. 4,444,355,556.

33333
2
―――――
66666

The product of any number of 3s multiplied by 2, is a number of 6s equal to the number of figures in the multiplicand: hence, we have only to square as many 6s as there are figures in the multiplicand.

3. What is the square of 6666666 Minus 4444444?

Ans. 4,938,270,617,284.

6666666
4444444
―――――
2222222

From any number of 6s subtract an equal number of 4s, and an equal number of 2s remain: hence, we only have to square a number of 2s equal to the given number of 6s.

4. What is the square of 44444444+55555555?

Ans. 9,999,999,800,000,001.

44444444
55555555
―――――
99999999

To any number of 4s add an equal number of 5s, the amount will be an equal number of 9s: hence, we only square a number of 9s equal to the number of 4s given.

5. What is the square of 888888÷4×3—222222+333-333?

Ans. 604,937,061,729.

4)888888
―――――
222222
3
―――――
666666
222222
―――――
444444
333333
―――――
777777^2=604,937,061,729.

Divide 8s by 4, the quotient will be 2s, multiply 2s by 3, the product will be 6s, take 2s from 6s and 4s remain, add

3s to 4s the amount will be 7s: you will perceive, the whole operation of Dividing, Multiplying, Subtracting, Adding and Squaring, can be performed in the mind, and the answer given immediately, without the aid of figures.

Note 1. To give the square of any number of figures multiplied by one or more figures that would increase each figure separately to a certain number, and divided by one or more figures that would reduce that number below ten, leaving no remainder.

EXAMPLES.

1. What is the square of 888888 multiplied by 2 and that product by 3, and the product divided by 6, and that quotient divided by 4? Ans. 49,382,617,284.

8 multiplied by 2 and 3 the product is 48, that divided by 6 and 4 the quotient is 2, therefore we have a number of 2s to square equal to the given number of 8s.

The product of the 8 in the units place multiplied by 2 and 3 (or by 6) is 48 units, the product of the 8 in the tens place is 48 tens, the product of the 8 in the hundreds place is 48 hundreds, the product of the next 8 is 48 thousands, the next 48 tens of thousands, next 48 hundreds of thousands, and if the results be set down separately would stand thus:

48	Units,
48	Tens,
48	Hundreds,
48	Thousands,
48	Tens of Thousands,
48	Hundreds of Thousands.

These separate results divided by 6 and 4 (or by 24) and the quotient figures would be as follows: 2 hundreds of thousands, 2 tens of thousands, 2 thousands, 2 hundreds, 2 tens, and 2 units, or 222222.

2. What is the square of $4444 \times 9 \div 12$?

Ans. 11,108,889.

3. What is the square of $6666666 \times 48 \div 96$?

Ans. 11,111,108,888,889.

4. What is the square of $8888 \times 56 \div 224$?

Ans. 4,937,284.

Multiplying by 48 and dividing by 96 is the same as taking 1 half, 56 and 224 as 1 fourth.

Note 2. To give the square of the amount of any number of rows of figures, with any number of figures in the

rows, added together, and the amount of another set of figures subtracted from them, that would reduce the amount of each column separately, below ten.

EXAMPLES.

1. What is the square of 888888+666666+777777+555555+444444+222222 Minus 333333+999999+111111+555555+888888?

Ans. 444,443,555,556.

When we add the figures in the above example, we find that the amount of each separate column in the minuend is 32, and the amount of each separate column in the subtrahend 26. The difference between the amounts of the separate columns is 6. The whole difference 666666. You will observe the answer can be given immediately from the mind.

2. From 44444444+55555555+77777777+88888888+88888888+44444444+99999999+66666666+11111111+22222222+33333333+77777777, take 99999999+88888888+33333333+7777777+999999999+88888888+66666666+55555555, and square the difference.

Ans. 9,999,999,800,000,001.

In this example the separate amount of each column in the minuend is 64, in the subtrahend 55: therefore the figures in the difference are all 9s,

Obs. We can give the square of the amount of any number of rows of figures, divided by a number that would reduce the separate amount of each column below ten, leaving no remainder; or with the amount of any other set of figures subtracted from them, having one kind of figures in a row, that the amount of each column may be reduced alike, and the difference divided by a number that would reduce the amount of each column below ten; or multiplied by any number, and divided by a number that would reduce the separate amount of each column below ten; or with all these operations combined.

Divide the whole amount by the amount of one column, the result will consist altogether of 1s.

Putting numbers together and separating them, is the whole principle of Arithmetic.

By trying a few examples you will find that if the separate amount of each column is the same, and you increase or

decrease each column alike, you have only to observe the changes in the amount of one column, through all the operations, to tell the whole amount.

Remarks. Of course the amount of any number of rows of figures, having one kind of figures in a row as above, can be given, and also the difference after subtracting another row of figures all alike, or the amount of another set of figures as above.

Also the product of any number of figures, all alike, multiplied by any figure whatever, and the quotient of any number of figures, all alike, divided by any other figure, can be given from the mind, or written down, without multiplying figures. The student will perceive that the operations can be varied; and many other methods will suggest themselves.

Obs. To give the square of any number of significant figures, with any number of ciphers on their right, we square the significant figures according to the preceding rules, then double the number of ciphers and place them on the right of the result.

In multiplying numbers with ciphers on their right, after having multiplied the significant figures, we place as many ciphers on the right of the product, as there are in both the factors.

Obs. 2. As the square of any number of figures, the figures being alike, can be given from the mind; it follows that the roots of these squares can be given as readily.

EXAMPLES.

1. What is the square root of 4,444,355,556?

Ans. 66,666.

$66666^2=4444355556$, and $\sqrt{44'44'35'55'56}=66666$.

2. What is the square root of 999999999998000000000001? Ans. 999,999,999,999.

Divide any number of figures of one kind, by any number of figures of the same kind; or others when the single figures in the divisor will divide the single figures in the dividend without a remainder: and the quotient will contain one figure more than the number of figures in the dividend exceeds the number of figures in the divisor; the order being 1, or the figure showing the number of times the single figures in the divisor are contained in the single figures of the

dividend, and as many 0s as there are figures in the divisor less one; then the same significant figure and ciphers repeated until we have the number required. If it does not come out even, the remainder will be a number of figures from the right of the dividend, equal to the excess of the number of figures in the dividend divided by the number of figures in the divisor.

EXAMPLES.

1. Divide 777,777,777 by 7777, Ans. 100,010 + 7.
2. Divide 8,888,888,888,888,888 by 4444.

Ans. 2,000,200,020,002.

Multiply any number of 9s by any figure, or any number of figures of one sort, by 9, the product will contain one figure more than the number of figures multiplied; all of which will be 9s, except the units figure and the left hand figure.

VARIOUS COMBINATIONS OF THE FOREGOING.

MISCELLANEOUS EXAMPLES.

1. What is the product of $\sqrt{9999800001} \times 132 \div 396$?

Ans. 33333.

2. Multiply 6,666,666,666,666,666,666,666,666 by 123,254, divide the product by 246,508, and square the quotient.

Ans. 11,111,111,111,111,111,111,108,888,888,888,888,888,888,888,889.

3. Put down the nine digits in their order six times, transposing half the number of rows, add, and square the amount.

Ans. 11,111,111,088,888,888,900.

In the above example the figures in the rows are not alike, but the separate amount of each column is the same.

4. Add together fifteen horizontal rows of 8s, each row containing one hundred and fifty six figures, twelve rows of 7s, four rows of 9s, one row of 5s, thirty-three rows of 4s, five rows of 6s, and eighteen rows of 3s: from this amount, take the amount of twenty-one rows of 4s, seventeen rows of 2s, three rows of 9s, thirty-eight rows of 8s, and four rows of 1s, all the rows containing the same number of figures; then multiply the difference by 232,423,268, or any other number, divide the product by a number four times as large, multiply the quotient by 3, and square the result.

Ans. Three hundred and twelve figures, all being 4s from the left to the first figure, left of the middle, which is 3, then all 5s to the units figure, which is 6.

If the student understands the foregoing pages, he can perform the above, and all similar operations in his mind; and tell the answers or write them down immediately.

The ingenious student will perceive, that the principles explained in the preceding pages, can be applied in many different ways not laid down in this little work.

By an examination of these principles, new ones may be discovered.

PART SECOND.

DECIMAL MENTAL ARITHMETIC.

This is a Mental System of combining Numbers, by resolving them into round or Decimal Numbers, and beginning at the left hand or highest place.

CASE 1.

TO SQUARE NUMBERS.

RULE.—Separate the given number into units, tens, hundreds, thousands, &c. Then square the thousands figure and remember the result; multiply the thousands figure by the figure of hundreds, double the result and add it to the other; square the figure of hundreds and add it; then multiply the thousands figure, and the figure of hundreds, by the figure of tens, double the result and add it; square the figure of tens

and add it; then multiply the thousands figure, the figure of hundreds, and the figure of tens, by the units figure, double the result and add it to the other; then square the units figure and add it.

EXAMPLES.

1. Square 16. Ans. 256.

The square of 10 is 100; 6 times 10 is 60, twice 60 is 120, added to 100 makes 220; 6 times 6 is 36 added makes 256.

2. Square 75. Ans. 5625.

The square of 7 tens is 4900; 5 times 7 tens is 350, this doubled is 700, which added to 4900 makes 5600; the square of 5 units is 25, added to 5600 is 5625.

3. Square 145. Ans. 21,025.

The square of 100 is 10,000; 100 multiplied by 40 is 4,000; this doubled is 8,000, which added to 10,000 makes 18,000; the square of 40 is 1600, added makes 19,600; 5 times 100 is 500, 5 times 40 is 200, added to 500 is 700, this doubled is 1400 which added to 19,600 is 21,000; the square of 5 is 25, which added makes 21,025.

4. Square 2324. Ans. 5,400,976.

2324 separated into round numbers is 2 thousand, 3 hundred, 2 tens, and 4 units. The square of 2,000 is 4,000,000; 2,000 multiplied by 300 is 600,000; doubled is 1,200,000, this added is 5,200,000; the square of 300 is 90,000, added makes 5,290,000; 2000 multiplied by 20 is 40,000; 300 multiplied by 20 is 6,000, added to 40,000 is 46,000, this doubled is 92,000, which added to 5,290,000 is 5,382,000; the square of 20 is 400, added is 5,382,400; 2000 multiplied by 4 is 8000, 300 multiplied by 4 is 1200, 20 multiplied by 4 is 80, the sum of these 9,280 doubled is 18,560; this added to 5,382,400, is 5,400,960; the square of 4 is 16, which being added to 5,400,960, makes 5,400,976.

With a little practice, this principle can be extended so as to combine numbers amounting to hundreds of thousands, and millions, with the greatest facility. You will perceive we do not have to multiply numbers higher than the common Multiplication Table; as we divide them into their round numbers, and only multiply the significant figures, remembering the number of ciphers in the two factors and placing them on the right of the result in the mind.

5. Square 12,444. Ans 154,853,136.

6. Square 236,000,000. Ans. 55,696,000,000,000,000. In this example we square 236 in the mind, and double the number of ciphers, and annex them to the result.

Note. To square numbers with Fractions to them, square the whole numbers according to the foregoing rule; then multiply the whole number by the fraction, double it, and add it; then square the fraction and add it.

EXAMPLES.

1. Square $62\frac{1}{2}$. Ans. $3906\frac{1}{4}$.

The Square of 62 is 3844; $\frac{1}{2}$ of 62 is 31, 31 doubled is 62, 62 added to 3844 is 3906; $\frac{1}{2}$ multiplied by $\frac{1}{2}$, is $\frac{1}{4}$ which added to 3906, is $3906\frac{1}{4}$.

2. Multiply $33\frac{1}{3}$ by $33\frac{1}{3}$. Ans. $1111\frac{1}{9}$.

$33 \times 33 = 1089$; $\frac{1}{3}$ of 33 is 11, $11 \times 2 = 22$; $1089 + 22 = 1111$; $\frac{1}{3} \times \frac{1}{3} = \frac{1}{9}$, 1111 plus $\frac{1}{9} = 1111\frac{1}{9}$.

3. What will $18\frac{3}{4}$ bushels of oats cost at $18\frac{3}{4}$ cents per bushel? Ans. $\$3,51\frac{9}{16}$.

$10 \times 10 = 100$; $10 \times 8 = 80$; $80 \times 2 = 160$, 100 plus $160 = 260$; $8 \times 8 = 64$; 260 plus $64 = 324$; $\frac{1}{4}$ of 18 is $4\frac{1}{2}$, $\frac{3}{4}$ will be $13\frac{1}{2}$, this doubled is 27; 324 plus $27 = 351$; $\frac{3}{4} \times \frac{3}{4} = \frac{9}{16}$ which, we find by Analysis as follows: $\frac{1}{4}$ of $\frac{1}{4}$ is $\frac{1}{16}$; then $\frac{1}{4}$ of $\frac{3}{4}$ will be $\frac{3}{16}$, and $\frac{3}{4}$ of $\frac{3}{4}$ will be $\frac{9}{16}$; 351 plus $\frac{9}{16} = 351\frac{9}{16}$

The operation when written out appears lengthy; but it can be performed in the mind in less time than $18\frac{3}{4}$ can be written down twice. In fact with a little practice the mind will merely glance through the operation and see the result.

4. How many square rods in an enclosure $77\frac{5}{7}$ rods long, and $77\frac{5}{7}$ rods wide? Ans. $6039\frac{25}{49}$ rods.

The square of 77 is 5929; $\frac{1}{7}$ of 77 is 11; $\frac{5}{7}$ is 55; 55 doubled is 110; 5929 plus $110 = 6039$; $\frac{1}{7}$ of $\frac{1}{7}$ is $\frac{1}{49}$; $\frac{1}{7}$ of $\frac{5}{7}$ is $\frac{5}{49}$; $\frac{5}{7}$ of $\frac{5}{7}$ is $\frac{25}{49}$; 6039 plus $\frac{25}{49} = 6039\frac{25}{49}$.

5. How many square feet in the floor of a room 28 feet by 28? Ans. 784 feet.

CASE 2.

TO MULTIPLY DIFFERENT NUMBERS TOGETHER.

RULE.—Separate the factors into their round numbers, then multiply the highest number in the multiplicand, by the highest number in the multiplier, in the mind, and remember the result: then multiply the next highest number in the mul-

tiplicand, by the highest number in the multiplier, add the result to the other, and remember it; then multiply the next highest number in the multiplicand by the highest number in the multiplier, and add it; and so proceed till all the separate numbers in the multiplicand are multiplied: then take the next highest number in the multiplier and multiply all the separate numbers of the multiplicand in the same order as before, still adding on the separate results as you multiply; then multiply all the separate numbers of the multiplicand, in the same order, by the next highest number in the multiplier: and so proceed, till all the round numbers in the multiplicand are multiplied by all the round numbers in the multiplier.

Or, when the multiplicand and multiplier, contain the same number of figures; for example, suppose each to contain three figures; multiply the hundreds together, then multiply the hundreds in the multiplicand by the tens in the multiplier, and the hundreds in the multiplier by the tens in the multiplicand; then multiply the tens together; the hundreds and tens in the multiplicand by the units in the multiplier, and the hundreds and tens in the multiplier by the units in the multiplicand; and lastly multiply the units together.

When there are Fractions to both factors, after having multiplied the whole numbers together, multiply the whole numbers in the multiplicand by the fraction to the multiplier, and the whole numbers in the multiplier by the fraction to the multiplicand; then multiply the fractions together.

When there is a fraction to one factor only, after having multiplied the integers together, multiply the other factor by that fraction.

EXAMPLES.

1. Multiply 1426 by 543. Ans. 774,318.

The above factors divided into their round numbers read thus: one thousand, four hundred, twenty, and six; and five hundred, forty, and three.

1000×500=500,000; 400×500=200,000; 500,000× 200,000=700,000; 20×500=10,000; 700,000 plus 10,000 =710,000; 6X500=3000; 710,000 plus 3,000=713,000; this disposes of the 500; then 1000X40=40,000; 713,000 plus 40,000=753,000; 400X40=16,000; 753,000 plus 16,000=769,000; 20 X40=800; 769,000 plus 800=769,800; 6X40=240; 769,800×240=770,040; this disposes

of the 40: then $1000\times3=3000$; $770,040+3000=773,040$; $400\times3=1200$; $773,040+1200=774,240$; $20\times3=60$; $774,240+60=774,300$; $6\times3=18$; $774,300+18=774,318$.

2. Multiply 456 by 345. Ans. 157,320.

3. Multiply 93 by 17. Ans. 1581.

The product of 90 multiplied by 10 is 900; 3 multiplied by 10 is 30; added to 900 is 930; 90 multiplied by 7 is 630; which added to 930 is 1560; 3 multiplied by 7 is 21; added to 1560 is 1581.

4. Multiply 89 by 5. Ans. 445.

5 times 80 is 400; 5 times 9 is 45; added to 400 is 445.

5. Multiply 538 by 12. Ans. 6456.

6. Multiply 64,397 by 9. Ans. 579,573.

$60,000\times9=540,000$; $4000\times9=36,000$; $540,000+36,000=576,000$; $300\times9=2700$; $576,000+2700=578,700$; $90\times9=810$; $578,700+810=579,510$; $7\times9=63$; $579,510+63=579,573$.

7. Multiply 931,078 by 23. Ans. 21,414,794.

8. Multiply 78 by 43. Ans. 3354.

9. Multiply 735 by 91. Ans. 66,885.

10. Multiply $48\frac{1}{2}$ by $16\frac{2}{3}$. Ans. $808\frac{1}{3}$.

$48\times16=768$, $48\times\frac{2}{3}=32$, $768+32=800$, $16\times\frac{1}{2}=8$, $800+8=808$, $\frac{1}{2}\times\frac{2}{3}=\frac{1}{3}$, $808+\frac{1}{3}=808\frac{1}{3}$.

11. Multiply $72\frac{4}{9}$ by $54\frac{5}{6}$. Ans. $3972\frac{10}{27}$.

$70\times50=3500$, $2\times50=100$, $3500+100=3600$, $70\times4=280$, $3600+280=3880$, $2\times4=8$, $3880+8=3888$, we multiply by the fractions analytically, as follows: $\frac{1}{6}$ of 72 is 12, $\frac{5}{6}$ is 5 times 12, which is 60: $3888+60=3948$, $\frac{1}{9}$ of 54 is 6, $\frac{4}{9}$ is 4 times 6, which is 24, $3948+24=3972$, $\frac{1}{9}\times\frac{1}{6}=\frac{1}{54}$, then $\frac{4}{9}\times\frac{1}{6}=\frac{4}{54}$, and $\frac{4}{9}\times\frac{5}{6}=\frac{20}{54}=\frac{10}{27}$, $3972+\frac{10}{27}=3972\frac{10}{27}$.

12. Multiply $793\frac{3}{4}$ by 32. Ans. 25,400.

We multiply 793 by 32, according to the foregoing method, and find the product to be 25376; we then take $\frac{3}{4}$ of the multiplier, 32, which is 24; which being added is 25,400.

13. Multiply 128 by $17\frac{3}{5}$. Ans. $2252\frac{4}{5}$.

Here we multiply 128 by 17, and find the product 2176; we then find $\frac{3}{5}$ of 128 thus: $\frac{1}{5}$ of 128 is $25\frac{3}{5}$, then $\frac{3}{5}$ of 128 will be 3 times $25\frac{3}{5}$, which is $75\frac{9}{5}=76\frac{4}{5}$, then $76\frac{4}{5}$ added to 2176 is $2252\frac{4}{5}$.

14. Multiply $87\frac{1}{2}$ by $33\frac{1}{3}$. Ans. $2916\frac{2}{3}$.

$87\times33=2871$, $87\times\frac{1}{3}=29$, $2871+29=2900$, $33\times\frac{1}{2}=$

$16\frac{1}{2}$, and $\frac{1}{2}\times\frac{1}{3}=\frac{1}{6}$, $16\frac{1}{2}+\frac{1}{6}=16\frac{4}{6}=16\frac{2}{3}$, and $16\frac{2}{3}$ to 2900 is $2916\frac{2}{3}$.

15. Multiply $264\frac{3}{4}$ by $31\frac{1}{4}$. Ans. $8,273\frac{7}{16}$

16. Multiply 452,368 by 3456. Ans. 1,563,383,808.

17. Multiply 5,824,000,000,000 by 32,000,000.

Ans. 186,368,000,000,000,000,000.

In the above example we multiply the significant figures—5824 and 32 together in the mind, and to the product 186,-368, annex the number of ciphers on both the factors.

The number of ciphers being fifteen, the product consists of twenty-one figures; read 186 quintillion, 368 quadrillion.

The whole operation can be readily performed in the mind, and the answer given from the mind.

18. What is the fourth power of 9? Ans. 6561.

The square or second power of 9 is 81; the cube or third power is $81\times9=729$; the fourth power, $729\times9=6561$.

19. What is the cube of 15? Ans. 3375.

20. What is the sixteenth power of 5?

Ans. 152,587,890,625.

21. What will 45 bushels of wheat amount to, at $87\frac{1}{2}$ cts. per bushel? Ans. $\$39,37\frac{1}{2}$.

22. Required the amount of 147 bushels of corn at $37\frac{1}{2}$ cents per bushel. Ans. $\$55,12\frac{1}{2}$.

23. What will 73 yards of muslin cost at 14 cents per yard?

Ans. $10,22.

24. What will $486\frac{1}{2}$ pounds of wool amount to at 34 cents per pound? Ans. $165,41.

Although the operations by this system appear prolix; the mind can run through them with astonishing rapidity.

By practice the student will learn to abbreviate his work, in the *mind*, and use contractions.

It will be seen that this method entirely obviates the necessity of *carrying*.

I do not think it necessary to enter into a full explanation of the principle upon which this system is founded, as it is perfectly *natural*, and will be understood by all.

This system is important to clerks and business men, as with a practical knowledge of *Mental calculation*, most common business questions can be performed in the *mind* quicker and with more certain accuracy, than with the pen.

Combining Numbers in the foregoing manner is well calculated to develop the *Organ of Numbering*, and will be found a most excellent exercise for the *memory*.

Calculating in the HEAD is NATURE's method, and is superior to any *artificial* system, as NATURE is superior to *art.*

PART THIRD.

THE CANCELING SYSTEM OF ARITHMETIC;

By which all business calculations are performed by one rule.

GENERAL RULE.— Draw a perpendicular line, then consider the nature of the question, and place those numbers which multiplied together compose the dividend, on the right, and those numbers which compose the divisor, on the left hand side of the line. Then cancel on opposite sides of the line all equal figures and numbers. If there are cyphers on both sides of the line, cancel the same number on both sides. If you can divide by a figure or number from one side into the other, cancel both numbers, and the quotient will remain on the side of the greater number. If any number greater than unity will divide any two numbers, one on each side of the line without a remainder, cancel both numbers, placing the quotients on the right and left of the numbers divided. Then multiply the figures that remain on the right hand side of the line for a dividend, and those on the left for a divisor. The quotient will be the answer. Should the divisor exceed the dividend the answer is a fraction.

EXAMPLES.

1. Multiply 36 by 8, and that product by 35, and divide the product by 12 multiplied by 8 times 7.

—12	36— 3
—8	8—
—7	35— 5

Ans. 15

Solution. 8 cancels 8, and 12 in 36 3 times, and 7 in 35 5 times; then 5 times 3 are 15, the answer.

2. Multiply 20 by 14, and divide the product by 10 multiplied by 7. Ans. 4.

3. Multiply 160 by 49, and 5, and divide the product 40 multiplied by 7 and 15. Ans. 9⅓.

REDUCTION.

EXAMPLES.

1. In 992 gills how many gallons? Ans. 31.

```
—4 | 992— 124— 31
—2 |
—4 |
```

Solution. 4 times 2 are 8, 8 in 992, 124 times, then 4 in 124 31 times.

2. In 480 square rods how many acres? Ans. 3.
3. In 604800 seconds how many days? Ans. 7.
4. In 288 inches how many yards? Ans. 8.
5. In 11520 grains how many pounds? (Troy) Ans. 2.
6. In 5120 drams (Avoir.) how many pounds? Ans. 20.

THE RULE OF THREE.

EXAMPLES.

1. If 9 bushels of wheat cost 12 dollars, what will 27 bushels cost? Ans, $36.

```
—9 | 27— 3
   | 12
     ——
Ans. 36.
```

2. *The above question reversed.* If 27 bushels of wheat cost 36 dollars, what will 9 bushels cost at the same rate? Ans. $12.

```
3—27 | 9—
     | 36
       ——
Ans. $12.
```

3. If $12 purchase 9 bushels of wheat what will $36 pay for at same rate? Ans. 27 bushels.

```
—12 | 36— 3
    | 9
      ——
Ans. 27.
```

4. If \$36 purchase 27 bushels of wheat, what will \$12 pay for at the same rate? Ans. 9 bushels.

$$\begin{array}{r|l} 3\text{—}36 & 12\text{—} \\ & 27 \end{array}$$

Ans. 9

5. If a stage coach run 30 miles in 3 hours, in how many hours would it run 120 miles? Ans. 12 hours.

6. If 18 men do a piece of work in 54 days, in how many days will 27 men do the same job? Ans. 36 days.

7. If 20 yards of cloth cost 120 dollars, how much will 5 yards cost? Ans. \$30

INTEREST, COMMISSION, INSURANCE, &c.

EXAMPLES.

1. What is the interest of \$96, for 18 months at 6 per cent? Ans. \$8,64.

$$\begin{array}{r|l} & 96\text{—}\ 8 \\ \text{—}12 & 18 \\ & 6 \end{array}$$

Ans. \$8,64.

2. What is the interest of \$120 for 8 months at 6 per cent? Ans. \$4,80.

3. What is my commission on \$8000 invested in land for B at 10 per cent? Ans. \$800.

$$\begin{array}{r|l} \text{—}100 & 8000\text{—}\ 80 \\ & 10 \end{array}$$

Ans. \$800.

4. Sold on consignment \$5000 worth of goods, what is my commission at 5 per cent? Ans. \$250.

5. What is the insurance on a house valued at \$10,000 at 3 per cent? Ans. \$300.

$$\begin{array}{r|l} \text{—}100 & 10000\text{—}\ 100 \\ & 3 \end{array}$$

Ans. \$300.

6. What is the insurance on a steam boat and cargo, valued at \$30,000, at 5 per cent? Ans. \$1500.

7. What will be the premium for insuring a building against loss by fire, valued at \$14,000, at 2 per cent?

C Ans. \$280.

8. What is the commission for selling goods to the amount of \$6400, at 7 per cent? Ans. \$448.

9. What is the per centage on \$1000 at 6 per cent? Ans. \$60.

FRACTIONS.

Remarks. In FRACTIONS the *denominator* is the *divisor*, and the *numerator* is the *dividend*.

Reduce all *mixed numbers* to *improper fractions.*

In DIVISION OF FRACTIONS *transpose the divisor.*

EXAMPLES.

1. Multiply $\frac{1}{2}$ of $\frac{2}{3}$ of $\frac{3}{4}$ of $\frac{4}{5}$, by $\frac{5}{6}$ of $\frac{6}{7}$ of $\frac{7}{8}$ of $\frac{8}{9}$, and give the answer.

—2	1
—3	2—
—4	3—
—5	4—
—6	5—
—7	6—
—8	7—
9	8—

Ans. $\frac{1}{9}$

2. Multiply $16\frac{1}{2}$ by $8\frac{2}{3}$.

—2	33—	11
—3	26—	13

Ans. 143.

Solution. 3 in 33, 11 times, and 2 in 26, 13 times; then 11 times 13 is 143.

3. Divide $\frac{4}{7}$ of $\frac{1}{5}$ of $\frac{5}{8}$, by $\frac{7}{8}$ of $\frac{6}{7}$ of $\frac{8}{12}$.

	7	4—	
	—5	1	
	—8	5—	
	—7	8—	
	—6	7—	
—2	—8	12—	6—

Ans. $\frac{1}{7}$.

4. Divide $12\frac{1}{2}$ by $2\frac{1}{2}$. Ans. 5.

—2	25—	5
—5	2—	

5. If $\frac{3}{4}$ of a yard of silk cost $\frac{3}{5}$ of a dollar, what will $\frac{5}{6}$ of a yard cost? Ans. $\$\frac{2}{3}$.

—3	4
6	5—
—5	3—

$\frac{4}{6}=\frac{2}{3}$

6. If $\frac{1}{2}$ of $\frac{2}{3}$ of $\frac{3}{4}$ of an acre of land, cost $\frac{1}{4}$ of $\frac{1}{5}$ of $\frac{10}{12}$ of \$300, what will 40 acres cost at the same rate?

Ans. \$2000.

7. If $\frac{1}{3}$ of a bushel of wheat cost $\frac{4}{9}$ of a dollar, what will $\frac{1}{2}$ bushel cost? Ans. $\$\frac{2}{3}$.

8. If $1\frac{3}{4}$ yards of cloth cost $\$\frac{7}{24}$, what will 2 yards cost? Ans. $\$\frac{1}{3}$.

9. $\frac{3}{4}$ of $\frac{4}{5}$ of $\frac{6}{7}$ of $\frac{5}{6}$ of $\frac{9}{10}$ of $\frac{7}{8}$ of $\frac{8}{9}$=how much? Ans. $\frac{3}{10}$

10. What is the continual product of 7, $\frac{1}{2}$, $\frac{5}{7}$ of $\frac{3}{8}$ and $3\frac{1}{9}$? Ans. $2\frac{11}{12}$.

To change fractions of different denominators to equivalent fractions with the least possible common denominator.

Note. In most business calculations, the least common denominator may be had by *inspection*. Or,

Divide the denominators by any number that will divide two or more without a remainder; thus divide until no two of the denominators and quotients can be divided by any number greater than one—then multiply the divisors, last quotients, and undivided denominators together; the product will be the least common denominator.

Divide the common denominator by each particular denominator, and multiply the quotients by their own numerators, the products will be the new numerators.

MENSURATION.

EXAMPLES.

1. How many acres in a lot that measures 80 rods in length, and 40 rods in breadth? Ans. 20.

—4	80—	20
—40	40—	

2. How many acres in a piece of land 320 rods in length and 160 rods in breadth? Ans. 320.

3. How many acres in a piece of land 320 rods square? Ans. 640.

4. How many feet of boards in 12 boards, that measure each 16 feet long and 15 inches wide? Ans. 240.

5. Required the area of a triangular piece of ground, the base of which measures 180 rods, the side answering to the perpendicular 80? Ans. 45 acres.

MECHANICAL POWERS.

THE LEVER.

Note.—In order to balance, the power multiplied by its distance from the fulcrum, must equal the weight multiplied by its distance from the fulcrum.

1. The long arm of a lever is 20 feet, the short arm 10 feet, what weight at the end of the short arm will balance 120 lbs. at the end of the long arm? Ans. 240 lbs.

$$\begin{array}{r|l} \cancel{10} & \cancel{20}\ 2 \\ & 120 \\ \hline \end{array}$$

Ans. 240

2. *The above example reversed.* What power at the end of the long arm, will balance 240 pounds at the end of the short arm? Ans. 120 lbs.

$$\begin{array}{r|l} 2\ \cancel{20} & \cancel{10} \\ & \cancel{240}\ 120 \end{array}$$

3. The long arm of a lever is 20 feet, the power 120 lbs. the weight balanced 240 pounds, what is the distance of the weight from the fulcrum? Ans. 10 feet.

4. The short arm of a lever is 10 feet, the weight 240 pounds, the power 120 pounds; required the length of the long arm of the lever.

Ans. 20 feet.

As *Proportion* is the foundation of Arithmetical knowledge, a correct understanding of its doctrine, with the *ratio* or *relation* of numbers, will enable the student to arrange any question for cancelation, to which the principle can be applied with advantage.

The Philosophy of the process of canceling is simply this: If we increase or decrease the *dividend* or *numerator*, and the *divisor or denominator* in the same *proportion*, the *ratio* of the terms is not altered.

PART FOURTH.

PERPETUAL MENTAL ALMANAC.

MNEMONIC SYMBOLS.

1 Gulp
2 Fob
3 Heated
4 Bedew
5 Teazel
6 Beans
7 Coop
8 Horn
9 Boast
10 Law
11 Howl
12 Gaiter
13 Dog
14 Daubed
15 Gazet'
16 Daniel
17 Books
18 Poor
19 Husk
20 Gilt
21 Few
22 Hotel
23 Beds
24 *Tzak*
25 Band
26 Coat
27 Draw
28 Bass
29 Leap
30 Hawk
31 Booted
32 Dow
33 Doub*el*
34 Boxes
35 Donor
36 Bacon
37 Pot
38 Hay-mow
39 Ball
40 Fox
41 *Dietic*
42 Goaded
43 Text
44 Genial
45 Coos
46 Harp
47 Bomb
48 Lot
49 Doff
50 Betel
51 Ham
52 Dab*b*
53 Gazed
54 Hunt
55 *Bucow*
56 Room
57 Damp
58 Balk
59 Wood
60 *De'jew*
61 Bead*el*
62 Texas
63 Gainer
64 Coon
65 Heart
66 Bas'aw
67 Veal
68 Heifer
69 *Beatic*
70 Head
71 Habit
72 Gazel
73 Danes
74 Baker
75 Pig
76 Dust
77 Gulf
78 Fool
79 Hats
80 Badg'
81 Taxed
82 Bent
83 Cow
84 Hares
85 Baser
86 Log
87 Dawn
88 Bat*ow*
89 Hail
90 Hogs
91 Bazar
92 Hand
93 Book-it
94 Pew
95 Hasel
96 Glair
97 Fog
98 Dated
99 Bidet
100 Dames

Value of Letters in the foregoing Symbols.

B and G	1,	L and V	5,	C and K	8,
H and D	2,	S and M	6,	Q and N	9,
J and T	3,	P and R	7,	X and Z	0.
F and W	4,				

Dominical Numbers for the Centuries.

101 B. C. to 2 B. C. inclusive	3
1 B. C. to 99 A. D. inclusive	2
100 to 199 inclusive	1

200	0	1200	4	2000	4
300	6	1300	3	2100	2
400	5	1400	2	2200	0
500	4	1500 old style	1	2300	5
600	3	1500 new style	5	2400	4
700	2	1600	4	2500	2
800	1	1700	2	2600	0
900	0	1800	0	2700	5
1000	6	1900	5	2800	4
1100	5				

NOTE.—To find when a year is Leap Year, divide the year of the century by 4: if there is no remainder it is Leap Year.

Old Style ends Oct. 4th, 1582 New Style begins Oct. 15th, 1582. Under the New Style every 4th Centurial year only is Leap Year. 1600, 2000, 2400, and so on for all succeeding centuries, are Leap Years.

To find when a Centurial year will be Leap year, divide the number of the century by 4: if there is no remainder, the Dominical Number for the century will be 4; if 1 remains 2; if 2 remains 0; if 3 remains 5. Thus the Centurial Dominical Numbers can readily be found for all succeeding centuries.

Dominical Numbers for the Months.

June 1; September and December 2; April and July 3; January and October 4; May 5; August 6; February, March and November 0.

Lunar Numbers for the Centuries.

101 B. C. to 2 B. C. inclusive	0
1 B. C. to 99 A. D. inclusive	4

100	9	1500	16	2900	22
200	14	1600	20	3000	27
300	19	1700	25	3100	1
400	23	1800	0	3200	6
500	28	1900	4	3300	11
600	3	2000	9	3400	16
700	8	2100	14	3500	20
800	12	2200	19	3600	25
900	17	2300	23	3700	0
1000	22	2400	28	5600	0
1100	27	2500	3	7500	0
1200	1	2600	8	9400	0
1300	6	2700	12	10,000	28
1400	11	2800	17		

NOTE.—To find the Lunar Numbers for the centuries for all succeeding ages:—Add 1 to the number of the century and divide it by 19, if 0 remains, the Lunar Number for the century will be 0; if 1 remains 4; if 2 remain 9; if 3 remain 14; if 4 remain 19; and so on in the order as above until the Cycle is completed. Thus the Centurial Lunar Numbers can readily be found for Hundreds of Thousands of years.

Lunar Numbers for the Months.

January and March 0; February, April and May 2; June and July 4; August 6; September 7; October 8; November 9; December 10.

NOTE.—Leap Year, after 29th February, the number for each Month is 1 more.

EXPLANATIONS.—The 100 symbols represent the 100 years of a century, and are so arranged that the value of the last consonant represents the Dominical Number for the year. The preceding consonant or consonants in the symbol representing the New Moon for January of that year; which we will call the Lunar Number for the year.

N. B.—The numbers for the centuries are for the Centurial year, or concluding year of the century; and the 99 succeeding years; *e. g.* the Dominical and Lunar numbers for 1800 are nothing, which means from 1800 to 1899 inclusive.

To find the Day of the Week for any month of any year.

RULE.—Add together the Dominical Numbers for the year, century and month; to that add the day of the month,

divide by 7, and the excess will be the day of the week for the date taken. When there is no remainder the day is Saturday.

In January and February of a Leap Year, deduct 1 after you have added the numbers together.

EXAMPLE.—What day of the week was January 8, 1815? The symbol for 15 is Gazet'; the last letter is T; the value of T is 3; the Dominical Number for 1800 is 0, for January 4; these added to the 8th day make 15, which divided by 7 leaves 1 remainder. 1st day of the week, Sunday.

To find the day of the month, knowing within a week before and after the day given.

RULE.—Find the day of the week for the nearest date known, and count from that to the day of the week given.

EXAMPLE.—What day of the month was Wednesday between the 5th and 13th of July 1804? By the rule for finding the day of the week, we find that the 5th of July 1804 was Thursday, and consequently the following Wednesday the 11th.

To find the Year, knowing the day of the month and day of the week, and within 5 years before and after the date.

RULE.—To the day of the month, add the Dominical Number for the month and century, divide by 7, and as much as the excess lacks being the day of the week given, so much will the Dominical Number for the year be, and that year (between the years given) whose Dominical Number will equal it, will be the year. In January and February of a Leap Year deduct 1, after adding the numbers together.

EXAMPLE.—What year was the 12th of October on Friday between 1487 and 1497? The Dominical Number for 1400 is 2, for October 4; these added to the 12th day, make 18, which divided by 7 leaves 4; this lacks 2 of being the 6th day of the week, Friday; and we find that the 92nd symbol Hand, has the Dominical Number 2; consequently 1492 was the year.

NOTE.—In adding the numbers it will be found convenient to cancel the 7s as you proceed.

To find the New Moon for any month in any year.

RULE.—To the Lunar Number for the year, add the Lunar Number for the century; divide by 30, and from the

surplus, subtract the Lunar Number for the month; the last remainder will be the day on which the New Moon falls in the given month.

EXAMPLE.—On what day will the New Moon fall in July, 1874? The symbol for 74 is Baker, the value of the consonants, which represent the Lunar Number for the year, (all being taken but the terminating one) is 18; Lunar Number for 1800 is 0; from these subtract 4, the Lunar Number for July, and 14 remains, hence the Moon changes July 14th, 1874.

The Full Moon falls on the 15th day before and after the change. First Quarter 7½ days after the change; third or last Quarter, 7½ days before the change, and after the full Moon.

To find the Moon's Age.

RULE.—Find the day on which the Moon changes in the month given; if the given day be after the change, subtract the day of the change from the given day of the month; the remainder will be the Moon's age on the given day. If the given day be before the change, subtract the number of days from the given day of the month to the change, from 30; the remainder will be the Moon's age for the day given.

Or, subtract the day of the change from 30; the excess will be the Moon's age at the commencement of the month; to this add the day of the month; the sum will be the Moon's age on the given day of the month: if the sum exceeds 30, cancel the 30s, the surplus will be the Moon's age; as she changes in 29½ days, or on the 30th day of her age.

To find the time of the Rising, Setting and Southing of the Moon on any day of her age.

RULE.—Multiply the Moon's age by 4, and divide the product by 5, the quotient is the hours, and the remainder multiplied by 12, the minutes after noon when she is on the meridian; but if this time exceeds 12, cancel the 12 hours, and the surplus is the time of her Southing in the morning.

N. B. From the change to the full, she comes to the meridian in the afternoon, but from the full to the change in the morning.

The Moon rises about 6 hours before she souths and sets near the same time after her southing.

Equinoxes and Solstices.

Vernal Equinox, March 20th; Summer Solstice, June 21st; Autumnal Equinox, September 23rd; Winter Solstice December 22nd.

Moveable Feasts, governed by the Moon.

Easter Sunday is the first Sunday after the full Moon, immediately succeeding the Vernal Equinox; it is easily found by the foregoing rules. Palm Sunday, is the 1st Sunday before Easter. Quinquagesima, or Shrove Sunday, is the 7th Sunday; Sexagesima Sunday, the 8th; and Septuagesima Sunday, the 9th Sunday before Easter. Low Sunday is the first Sunday after Easter; Rogation Sunday is the 5th Sunday after Easter; Whit Sunday, or Pentecost, the 7th Sunday, and Trinity Sunday, the 8th Sunday after Easter. Good Friday is the Friday before Easter. Ash Wednesday, or 1st day of Lent, is the 1st Wednesday after Quinquagesima Sunday. Shrove Tuesday, is the day before Ash Wednesday. Ascension Day, or Holy Thursday, is the 1st Thursday after Rogation Sunday. Corpus Christi, is the next Thursday after Trinity Sunday, Advent Sunday, is always the 4th Sunday before Christmas.

Rising and Setting of the Sun, &c.

	H.	M.		H.	M.
Jan. and Nov.	7	15	May and July	4	50
Feb. and Oct.	6	35	June	4	30
March and Sept.	6	0	December	7	30
April and Aug.	5	20			

The foregoing Numbers represent the time of the Sun's Rising on the 20th day of each month in the year. For any day of the month between these dates, add 1 minute for each day between the last previous date and the given day, from the Summer Solstice to the Winter Solstice; and subtract 1 minute from the Winter Solstice to the Summer Solstice. Near the Equinoxes the difference is 2 minutes per day; and near the Solstices 1 minute for 2 days.

Subtract the time of the Sun's rising, from 12 hours, for the time of the Sun's setting. Double the time of the Sun's setting for the length of the day, and the time of the Sun's rising for the length of the night.

Sun's Place in the Zodiac.

Enters the Constellation *Aries*, March 20th; *Taurus*, April 20th; *Gemini*, May 21st; *Cancer*, June 21st; *Leo*, July 23rd; *Virgo*, August 23rd; *Libra*, September 23rd; *Scorpio*, October 23rd; *Sagittarius*, November 22nd; *Capricorn*, December 22nd; *Aquarius*, January 20th; *Pisces*, February 19th.

Sun's Declination.

From the Vernal Equinox, to the Autumnal Equinox, the Sun is North of the Equator; and from the Autumnal Equinox to the Vernal Equinox, South of it. At the Summer Solstice his declination is 23½ degrees North; at the Winter Solstice 23½ degrees South; at the Equinoxes nothing. He passes over on an average 8 degrees each month though when near the Solstices, not more than 3 or 4 degrees, and when near the Equinoxes 10 or 12 degrees.

Sun Fast or Slow; or, Equation of Time.

From the 16th of April to the 16th of June the Sun is fast; from the 16th of June to the 1st of September, slow; from the 1st of September to the 25th of December, fast; and from the 25th of December to the 16th of April, slow. On the above mentioned days the Sun and Clock agree.

The greatest difference between Solar and Clock time is about 16¼ minutes. The 15th of May the Sun is 3 minutes fast: 25th of July 6 minutes slow: 1st of November 16 minutes fast: and the 12th of February 14 minutes slower than the true Clock time.

Moon's Place; or, Sign.

At the new Moon the Moon will be in the sign the Sun is in at the time of the change: *e. g.* if the Moon change between the 20th March and 20th April, her sign will be in Aries at the time of the change; at the change between April 20th and May 21st in Taurus, &c. (see Sun's place in the Zodiac.)

The Moon passes through, on an average, a sign in 2½ days; hence, at her 1st quarter, she will be in the 3rd sign from her place at the change; at the full, in the 6th, or opposite sign from her place at the change; at the 3d quarter, in the 9th sign from the place of her change; having performed ¾ of her revolution around the earth. From these data the Moon's place on any day of her age will easily be found.

The Human System, as supposed to be governed by the 12 Constellations, according to Ancient Astrology.

Aries, the Ram—Head
Taurus, the Bull—Neck
Gemini, the Twins—Arms
Cancer, the Crab—Breast
Leo, the Lion—Heart
Virgo, the Virgin—Bowels
Libra, the Balance—Reins
Scorpio, the Scorpion—Secrets
Sagittarius, the Archer—Thighs
Capricornus, the Goat—Knees
Aquarius, the Waterman—Legs
Pisces, the Fishes—Feet

Solar Eclipses visible in the United States during the next 30 years.

Y.	M.	D.	H.	Digits Eclipsed.
1847	October	9	1 P. M.	
1848	March	5	8 A. M.	6
1851	July	28	8 A. M.	3
1854	May	26	4 P. M.	11
1858	March	15	7 A. M.	2
1859	July	29	5 P. M.	2
1860	July	18	7 A. M.	6
1861	December	31	8 A. M.	4
1863	May	17	1 P. M.	
1865	October	19	9 A. M.	3
1866	October	8	11 A. M.	
1867	March	6		
1868	February	23	10 A. M.	
1869	August	7	5 A. M.	10
1870	December	22		
1873	May	26		
1874	October	10		
1875	September	29	6 A. M.	11
1876	March	25	4 P. M.	4

This table can be extended backwards, or continued, by subtracting or adding the *Saros*, or Chaldean Period of 18 years, 11 days, 7 hours, 42 minutes and 31 seconds.

The number of Eclipses in 1 year, cannot be less than 2 nor more than 7; in the former case they will both be of the Sun; in the latter 5 of the Sun, and 2 of the Moon.

As the Moon's Nodes *fall back* in the Ecliptic, at the rate of about $19\frac{1}{3}$ degrees annually; the eclipses happen sooner

each year by about 19 days. The Moon passes from one of her Nodes to the other in 173 days, which is the period between two successive eclipses of the Sun or of the Moon.

When the Moon is in Apogee she is most distant from the Earth: when in Perigee, nearest the Earth.

The Earth is in her Perihelion about the 1st of January; and in Aphelion the 1st of July, being 3 millions of miles nearer the Sun in Winter than in Summer.

The velocity of the Earth through space, in her orbit around the Sun, is 68,000 miles an hour; or more than 1,000 miles per minute.

To find Locust Year in Muskingum Valley.

RULE.—Add 7 to the given year, and divide the sum by 17, if there is no remainder it is Locust year; but if there is a remainder, the remainder will show the year of the *Cicada Period,* or the number of years from the last Locust year.

To tell the Hour of the Day or Night, on any Meridian East or West, the Time being known on a given Meridian.

RULE.—If the place be 1 degree East, the Time will be 4 minutes later; if 5 degrees East 20 minutes later; if 15 degrees East 1 hour later, &c. The same number of degrees West, the hour of the day or night will be the same number of minutes or hours earlier.

The Rising, Setting and Southing of the Zodiacal Constellations.

This can be told pretty nearly by knowing the Sun's place in the Zodiac, and the time of his rising and setting.

The Constellation which the Sun is in at any time will rise come to the Meridian, and set, with the Sun. The 6th or opposite Constellation from the Sun, will rise, come to the meridian, and set, in opposition to the Sun; rising as the Sun sets, coming to the meridian at midnight, and setting as the Sun rises. The 3rd Constellation in advance (or East) of the Sun, will rise, come to the meridian, and set, 6 hours later than the Sun. The 3rd Constellation behind (or West) the Sun, will rise, come to the meridian, and set, about 6 hours earlier than the Sun. The difference amounts to about 2 hours for each Constellation, the whole twelve performing their *apparent* revolution around the Earth, (caused by the Earth's Diurnal motion) in 24 hours.

NOTE.—Aries is the *first sign*, though now the *second Constellation* in the Zodiac; Taurus is now the *second sign* and *third Constellation* of the Zodiac; Gemini is the *third sign* but *fourth Constellation* in the order of the Zodiac, and so on; each *Constellation* having advanced 1 *sign* in the last 2140 years, in consequence of the *recession* of the Equinoxes and Solstices, or the *precession* of the Stars; so that the Fishes now occupy the same place in the Zodiac that Aries did 2140 years ago; consequently the Fishes are now the first in order of the 12 Constellations of the Zodiac, and are now called the "Leaders of the Celestial Hosts."

Precession of the Equinoxes.

The Equinoctial Points *recede* upon the Ecliptic, at the rate of about 50¼ seconds of a degree every year; in 71⅔ years they *fall back* a degree. At the present rate of motion, the precession (or more properly the *recession*) of the Equinoxes amounts to 30 degrees, or 1 sign, in 2140 years. They are 6,575 years in passing through the first quarter of the Ecliptic; about 220 years *less* in passing through the second quarter; 220 less in passing through the third, and so on, moving the whole distance *backwards*, around the Ecliptic in about 25,000 years, which may be called the period of the Equinoctial Cycle.

INSTRUCTIONS TO THE STUDENT.

The Author designs the foregoing pages of the "Mental Almanac" to be committed to memory by the Student and thoroughly studied.

The Student may commence by committing the "Mnemonic Symbols," which, by connecting them together, and practicing the *Association of Ideas*, can readily be done. It matters not how they are connected or associated together,—the connection or association which first strikes the mind will generally be the best; for illustration, we will commence at Gulp 1, the second symbol is Fob, you may put (in imagination) a *gulp* of pork, or any thing whatever, in your *fob*; the 3rd symbol is Heated, you may suppose the gulp in your fob to become *heated*; the 4th symbol Bedew, may be connected to Heated, by supposing the *dew* to allay

the heat; the Teazel may be used to brush off the dew, which will connect the 5th symbol, and so on to the 100th symbol, connecting them in the most simple manner, or by the first association that strikes the mind.

To return to the 1st symbol, you may think of the manner in which you disposed of the gulp, you will immediately recollect that you put it in your fob, which will bring to mind the 2nd symbol; you will then remember that your fob became heated, which will bring to memory the 3rd symbol; the dew to allay the heat and the teasel to brush off the dew will bring to mind the 4th symbol Bedew, and the 5th symbol Teazel, &c. This method of connecting words, phrases and sentences together, by association, although it may appear simple, will be found very useful in committing to memory.

The 100 symbols in their order, and with their Orthography, must be so thoroughly committed to memory that the student can repeat them forwards or backwards, and call any symbol to memory immediately on hearing its number. In committing the symbols, the number of each symbol should be repeated with the symbol, as follows: Gulp 1, Fob 2, Heated 3, &c., repeating each symbol with its number once, twice, or as often as you please, in order that each symbol may be associated with its number.

The value of the Consonants, the Dominical and Lunar Numbers, &c., must all be committed thoroughly to memory, that the Student may be enabled to call them to mind instantly; and when he has done this, and become thoroughly acquainted with the rules, he will be no longer under the necessity of referring to the book, which is intended to be what its title indicates—a "*Mental* Almanac."

Note.—Minute exactness in a work of this kind will not be expected, though, I believe, it will be found as nearly correct, as most of the Almanacs. The Phases of the Moon, may vary some hours from the time given in this work, and consequently occur "the day before or day after" the time given in this work: *e. g.* according to the rules in this work, the Moon may change the 8th of March, and possibly by the Almanacs, the evening of the 7th, or the morning of the 9th, lacking a few hours of being on the 8th. The Day of the Month and Week, &c., will be found strictly correct, and the whole sufficiently exact for all practical purposes.

RATIONAL MNEMONICS:

OR CULTIVATION OF THE MEMORY BY ASSOCIATION OF IDEAS.

Memory is that faculty by which ideas are retained in the mind. Recollection may be defined—the power of recalling dormant ideas; although memory and recollection are frequently used synonymously.

To descant upon the immense value of a good memory, would be superfluous. It is the only faculty by which knowledge of any kind, is ever acquired or retained. If deprived of memory, the whole past would be a gulf of impenetrable darkness; while of the future we could form no conjecture, and the present would be but a confused dream. Memory is the great store-house of the mind; which never becomes full, how-much-so-ever you may put in it. It is from this magazine that reason equips herself to fight the battles of truth; and fancy wings herself to soar almost beyond the reach of thought.

Memory then is of vast importance, and he who wishes to cultivate his intellect, and expand his mind, he who wishes to become a scholar, a historian, or especially an orator, should cultivate, *every kind of memory*. This must be done by exercise, which is the only way to increase the power of any faculty; for as the arm becomes stronger by using the axe, or hammer; the organ of numbers, is strengthened by calculating; the power of reasoning, is increased by thinking and reflecting; the argumentative power, by debating; and the memory by *trying to remember*.

If you wish to remember every thing as nearly as possible charge your memory with every thing you observe—with every thing that transpires; take as few notes as possible—or none; there is no more effectual way of weakening and destroying the memory, than by noting every thing you wish to remember, down on paper. for it is an established *Law*, that if we neglect to exercise an organ or faculty in its proper function, its power will *degenerate*.

In reading (History for instance,) strive to impress all the leading and important facts, numbers, dates, localities, &c., in their proper order, upon the mind; and afterwards frequently recall them in their order, until they are permanently fixed in the memory. In travelling, charge your memory